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Ichikawa

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(54) **SHEET CONVEYING DEVICE AND IMAGE FORMING APPARATUS PROVIDED WITH THE SAME**

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B65H 5/02 (2006.01)
B65H 5/04 (2006.01)
B65H 5/06 (2006.01)

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CPC ***B65H 5/062*** (2013.01); ***B65H 5/068*** (2013.01)

(58) **Field of Classification Search**
CPC B65H 5/06; B65H 5/062; B65H 2404/14; B65H 2404/143; B65H 2404/144; B65H 5/068
See application file for complete search history.

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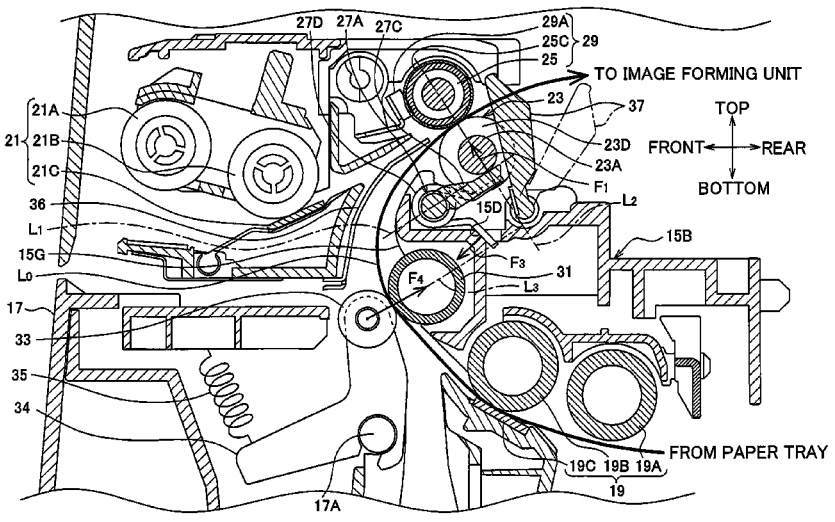
(57) **ABSTRACT**

A sheet conveying device includes: first, second and third rollers, a conveying member, a frame, a first pressing member, and a force-generating unit. The first and second rollers rotate while nipping the sheet therebetween. The third roller and the conveying member nip the sheet therebetween. The frame is elongated parallel to an axis about which the third roller rotates and supports the third roller. The first pressing member applies a first pressing force to an axial center of the first roller to press the first roller toward the second roller and applies a reaction force of the first pressing force to the frame to press the frame in a direction toward the conveying member. The force-generating unit generates a nipping force for nipping the sheet between the third roller and the conveying member and applies an urging force to the frame in a direction away from the conveying member.

15 Claims, 6 Drawing Sheets



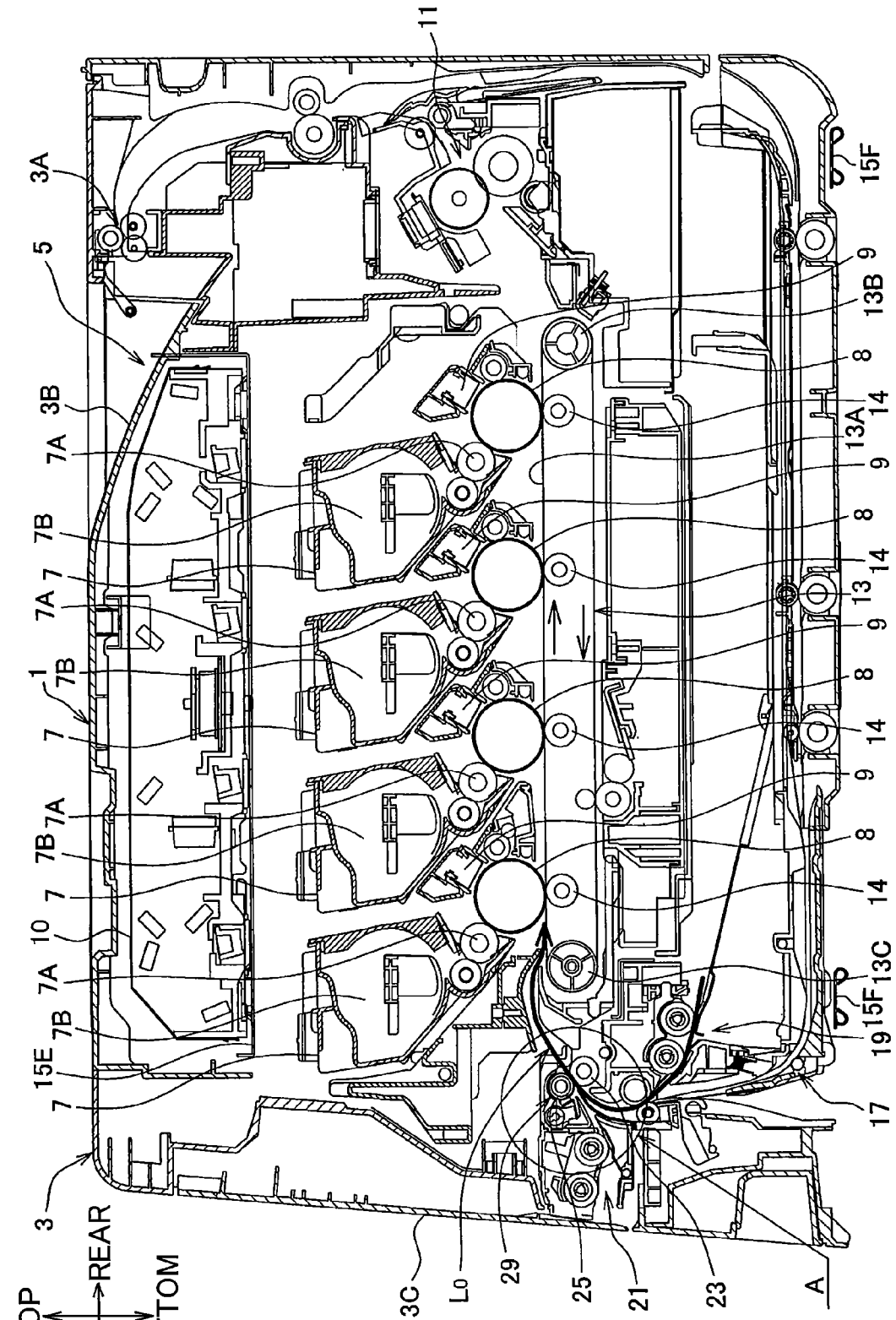

11
3A
5
3B
7A
7B
7
1
10
15E
3
15F
13B
13A
13
13C
19
17
3C
Lo
29
25
21
23
A
TOP
REAR
FRONT
BOTTOM

FIG.1

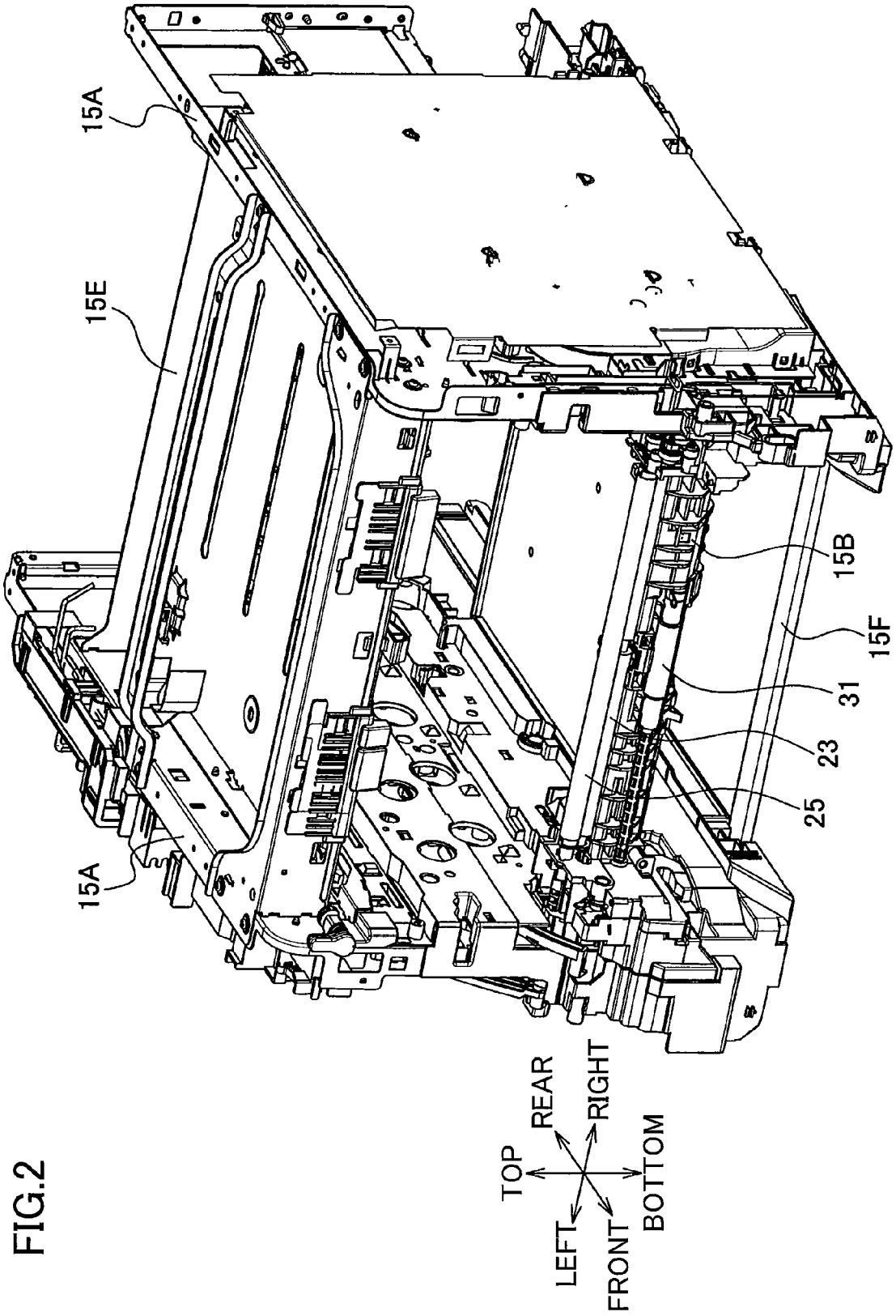
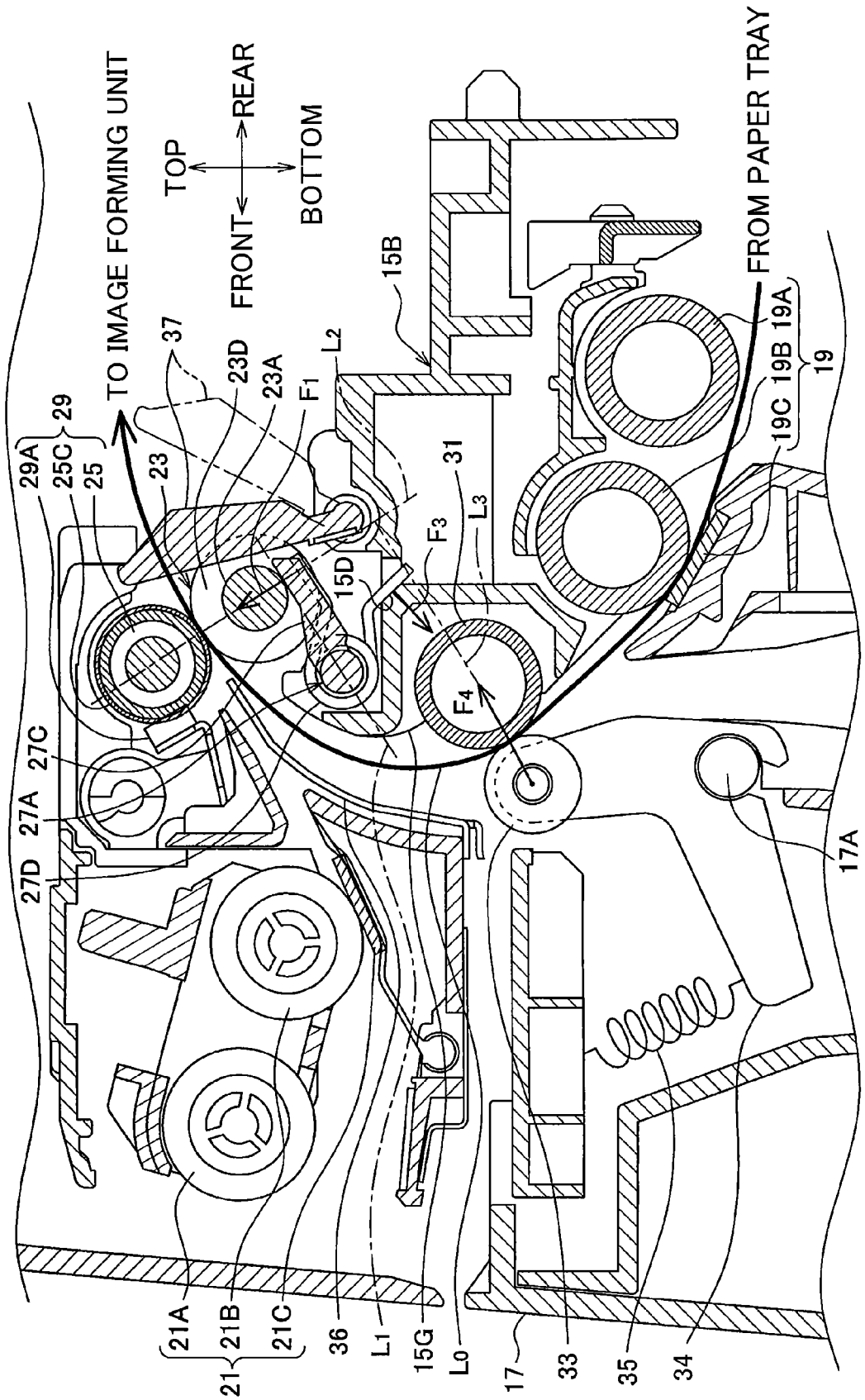


FIG.2


TO IMAGE FORMING UNIT
TOP
REAR
FRONT
BOTTOM
FROM PAPER TRAY
29
29A
25C
25
37
23
23D
23A
F1
L2
15B
31
L3
F3
15D
F4
19
19A
19B
19C
27C
27A
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L1
15G
L0
17
33
35
34

FIG.3

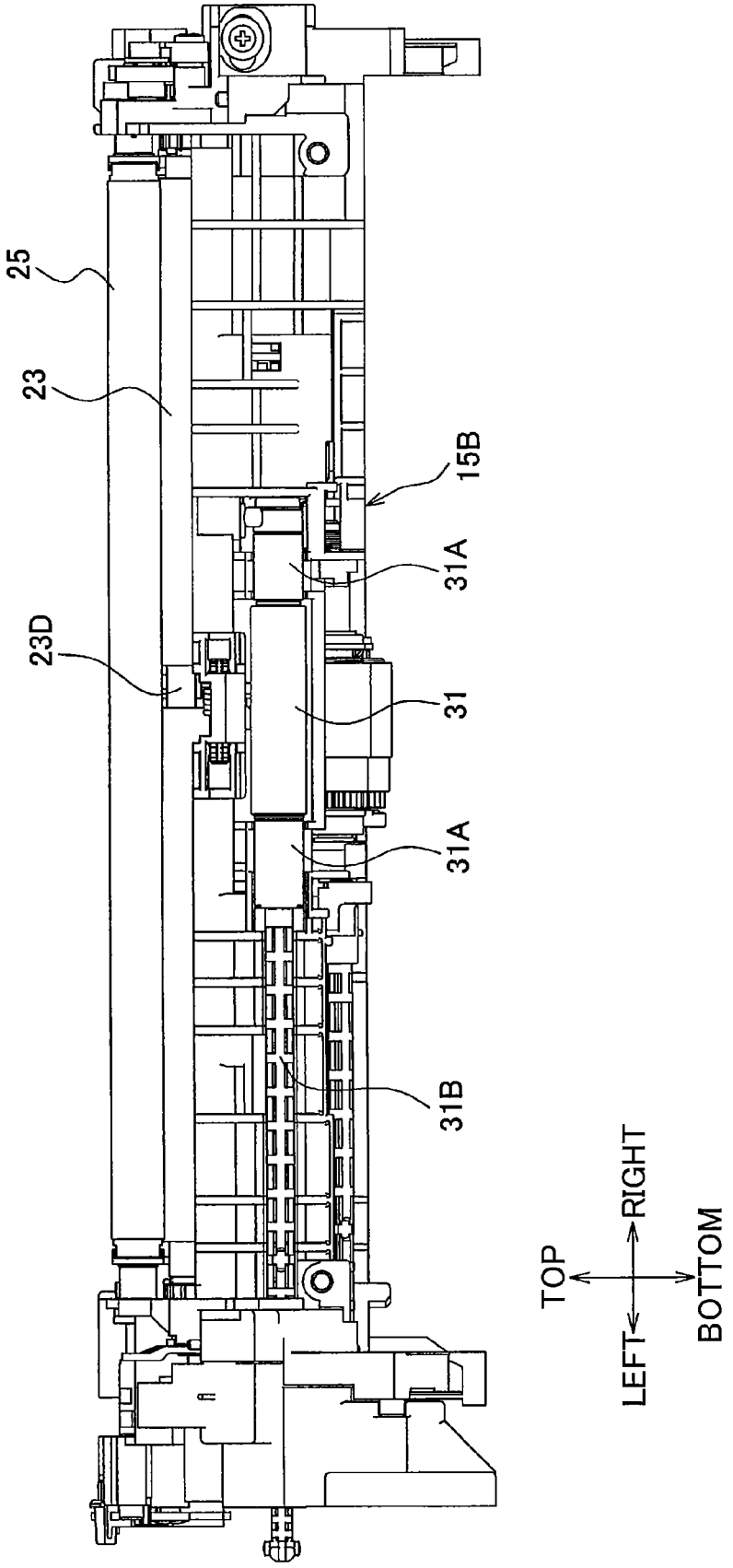

FIG.4

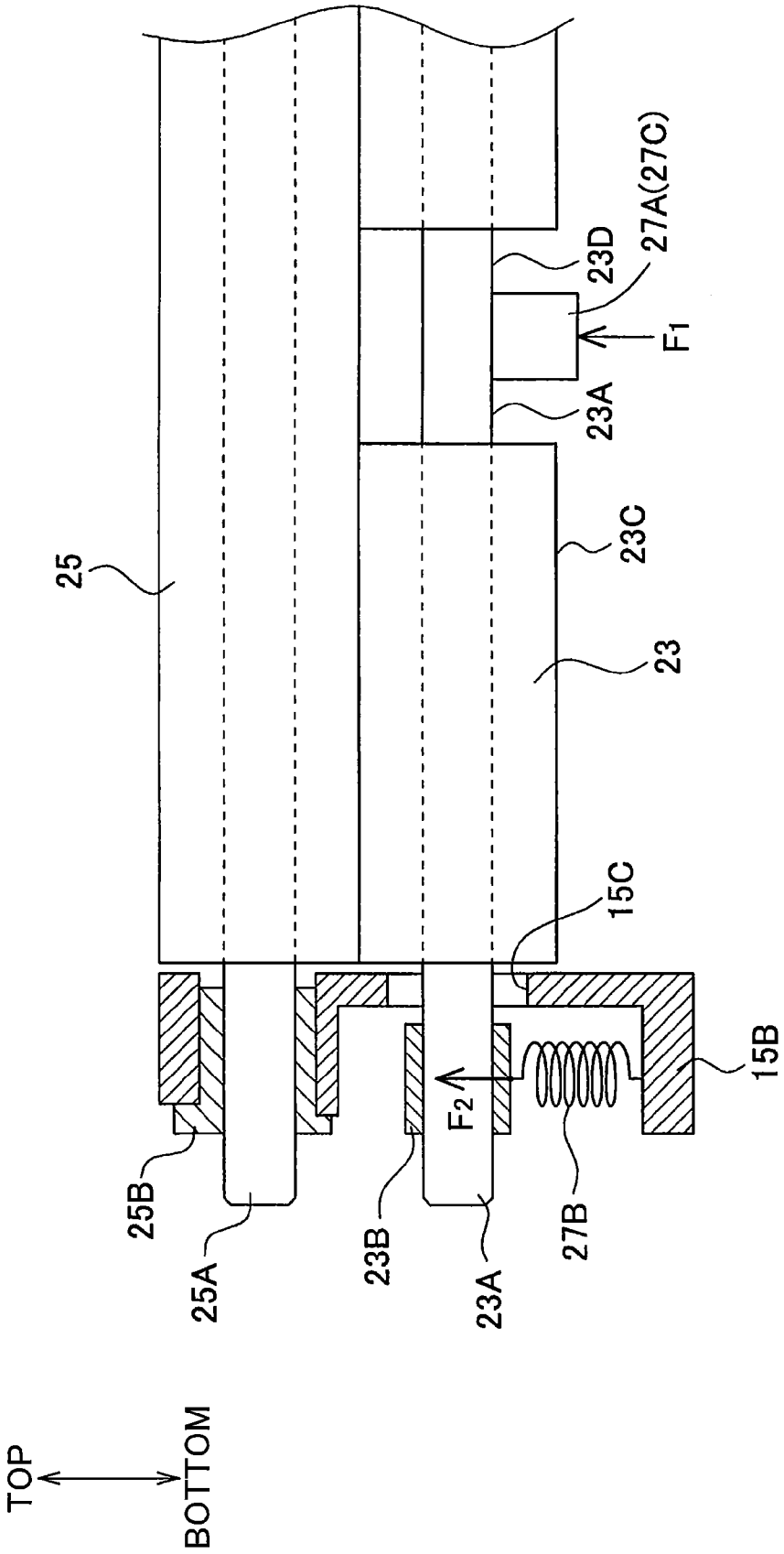
25
23C
23D
27A(27C)
F1
23A
23
15C
15B
F2
25B
25A
23B
23A
27B
TOP
BOTTOM

FIG.5

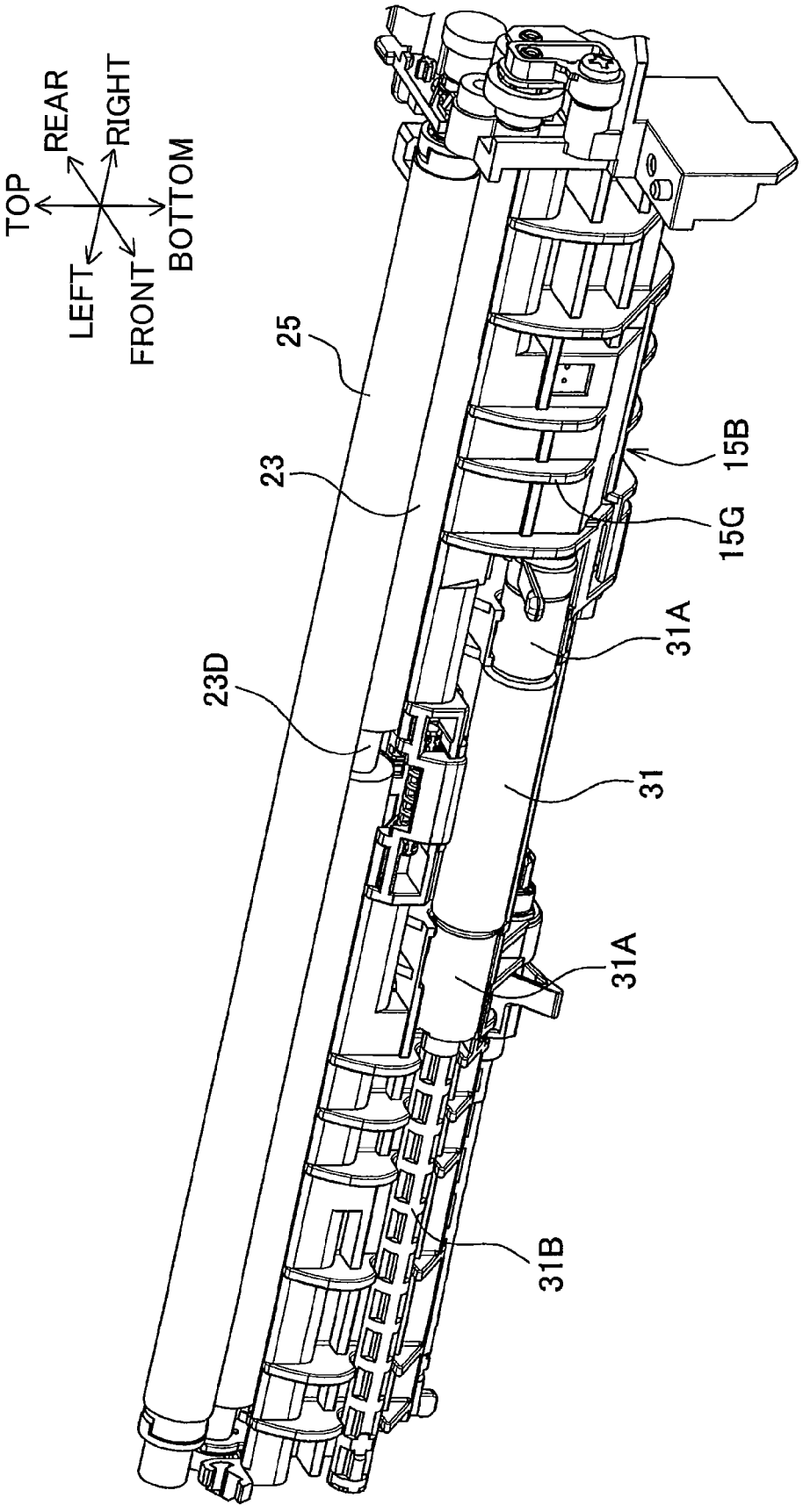
TOP
REAR
RIGHT
BOTTOM
LEFT
FRONT
25
23
23D
15B
15G
31A
31
31A
31B

FIG.6

SHEET CONVEYING DEVICE AND IMAGE FORMING APPARATUS PROVIDED WITH THE SAME

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2013-142729 filed Jul. 8, 2013. The entire content of the priority application is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a sheet conveying device that conveys sheets, and to an image forming apparatus provided with this sheet conveying device.

BACKGROUND

Normally, a roller used to convey sheets is supported at both ends of its rotational axis. When a load acts on the roller, the roller bows in its axial center region. Consequently, compressive force applied by such rollers to a sheet and forces such as pressure between the contacting surfaces of the sheet and rollers and pressure between the contacting surfaces of the rollers (hereinafter collectively referred to as "the nipping force") are smaller in the axial center region of the rollers.

Since slippage is more likely to occur between the sheet and rollers when the nipping force is smaller, a reduced nipping force in the axial center region of the rollers may lead to sheet-conveying problems. To address this issue, the invention disclosed in Japanese unexamined patent application publication No. HEI-8-91635, for example, attempts to avoid a reduced nipping force in the center region of a pair of rollers disposed in confrontation with each other by applying pressure to the axial center region of at least one roller in a direction toward the other roller.

SUMMARY

This sheet conveying device is provided with a pressing member, such as a spring. One end of the pressing member exerts a force on one of the rollers, pressing the roller toward the other roller. Consequently, a force generated as a reaction to the pressing force (hereinafter referred to as "the reaction force") must be absorbed and is normally absorbed by a reinforcing member, such as a frame.

However, there is a possibility that the frame incurring the reaction force will deform and bow over time. If the frame deforms in this manner, the rollers may not be able to produce the required nipping force in their axial center region, even with the pressure applied by the spring or the like.

In view of the foregoing, it is an object of the present invention to provide a sheet conveying device that prevents a reduction in a nipping force between a pair of rollers by restraining deformation of a frame used to absorb a reaction force to a force acting to press the pair of rollers.

In order to attain the above and other objects, the present invention provides a sheet conveying device configured to convey a sheet along a sheet-conveying path. The sheet conveying device may include: a first roller; a second roller; a third roller; a conveying member; a frame; a first pressing member; and a force-generating unit. The first roller may be configured to rotate while contacting the sheet. The first roller may rotate about a rotational axis extending in an axial direction and have an axial center region in the axial direction. The second roller may be disposed in confrontation with the first roller. The second roller may be configured to rotate while nipping the sheet in cooperation with the first roller. The third roller may be disposed spaced apart from the first roller. The third roller may rotate about a rotational axis extending in the axial direction and be configured to rotate while contacting the sheet. The conveying member may be disposed in confrontation with the third roller. The conveying member may be configured to nip the sheet in cooperation with the third roller. The frame may be elongated in the axial direction and support the third roller. The first pressing member may be configured to apply a first pressing force to the axial center region of the first roller to press the first roller toward the second roller. The first pressing member may be further configured to apply, to the frame, a reaction force generated as a reaction to the first pressing force to press the frame in a direction toward the conveying member. The force-generating unit may be configured to generate a nipping force for nipping the sheet between the third roller and the conveying member. The force-generating unit may be further configured to apply an urging force to the frame in a direction away from the conveying member.

According to another aspect, the present invention provides an image forming apparatus that may include: a sheet conveying device configured to convey a sheet along a sheet-conveying path; and an image forming unit configured to form an image on the sheet conveyed by the sheet conveying device. The sheet conveying device may include: a first roller; a second roller; a third roller; a conveying member; a frame; a first pressing member; and a force-generating unit. The first roller may be configured to rotate while contacting the sheet. The first roller may rotate about a rotational axis extending in an axial direction and having an axial center region in the axial direction. The second roller may be disposed in confrontation with the first roller. The second roller may be configured to rotate while nipping the sheet in cooperation with the first roller. The third roller may be disposed spaced apart from the first roller. The third roller may rotate about a rotational axis extending in the axial direction and be configured to rotate while contacting the sheet. The conveying member may be disposed in confrontation with the third roller. The conveying member may be configured to nip the sheet in cooperation with the third roller. The frame may be elongated in the axial direction and support the third roller. The first pressing member may be configured to apply a first pressing force to the axial center region of the first roller to press the first roller toward the second roller. The first pressing member may be further configured to apply, to the frame, a reaction force generated as a reaction to the first pressing force to press the frame in a direction toward the conveying member. The force-generating unit may be configured to generate a nipping force for nipping the sheet between the third roller and the conveying member. The force-generating unit may be further configured to apply an urging force to the frame in a direction away from the conveying member.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings;

FIG. **1** is a center cross-sectional view of an image forming apparatus provided with a sheet conveying device according to one embodiment of the present invention;

FIG. **2** is a perspective view illustrating frames of the image forming apparatus including a pair of main frames and a sheet-feeding frame;

FIG. **3** is a cross-sectional view of the sheet conveying device according to the embodiment;

FIG. **4** is a front view of the sheet conveying device according to the embodiment;

FIG. **5** is a schematic view illustrating structures for supporting a first roller and a second roller; and

FIG. **6** is a perspective view of the sheet conveying device according to the embodiment.

DETAILED DESCRIPTION

1. Overall Structure of Image Forming Apparatus

An image forming apparatus provided with a sheet feeding device as a sheet conveying device according to one embodiment of the present invention will be described with reference to FIG. **1**. A detailed structure of the sheet feeding device will be described later with reference to FIG. **2** through **6**, wherein like parts and components are designated by the same reference numerals to avoid duplicating description.

Arrows indicating directions and the like in the drawings are intended to facilitate understanding of how the drawings relate to each other, and the present invention is not limited to these specified directions. The present invention is provided with at least one of those parts and components designated with symbols or reference numerals, except when the parts and components are specifically specified as being "a plurality of," "two or more," or the like.

In the following description, the terms "upward", "downward", "upper", "lower", "above", "below", "beneath", "right", "left", "front", "rear" and the like will be used assuming that the image forming apparatus **1** is disposed in an orientation in which it is intended to be used. More specifically, in FIG. **1**, a left side and a right side are a front side and a rear side, respectively. Further, in FIG. **1**, a top side and a bottom side are a top side and a bottom side, respectively. Further, in FIG. **1**, a near side and far side are a right side and a left side, respectively.

As illustrated in FIG. **1**, the image forming apparatus **1** includes a casing **3**, and an electrophotographic image forming unit **5** accommodated in the casing **3**.

The image forming unit **5** is adapted to form images on sheets of paper or another recording medium. The image forming unit **5** includes a plurality of (four in the embodiment) developer cartridges **7**, a plurality of (four in the embodiment) photosensitive drums **8**, a plurality of (four in the embodiment) chargers **9**, an exposure unit **10**, a fixing unit **11** and an endless belt **13**.

The four developer cartridges **7** are juxtaposed in a juxtaposed direction (front-rear direction in the embodiment) inside the image forming unit **5**. Each of the developer cartridges **7** includes a developing roller **7**A, and a storage section **7**B. The storage section **7**B serves to store developer therein. From one side (front side in the embodiment) to another side (rear side in the embodiment) of the juxtaposed direction, the storage sections **7**B of the developer cartridges **7** accommodate developer in the color order yellow, magenta, cyan, and black.

Four each of the photosensitive drums **8** and the chargers **9** are provided to correspond to the four developer cartridges **7**. The photosensitive drums **8** are adapted to carry developer images on their circumferential surfaces. The chargers **9** are adapted to apply electrical charges to the corresponding photosensitive drums **8**. Once charged, the photosensitive drums **8** are exposed by the exposure unit **9**, forming an electrostatic latent image on each photosensitive drum **8**. The developing rollers **7**A supply developer stored in the corresponding storage sections **7**B to the corresponding photosensitive drums **8**. Through this operation, developer images corresponding to the electrostatic latent images are carried on the circumferential surfaces of the photosensitive drums **8**.

The endless belt **13** is looped around and supported on a drive roller **13**B and a follow roller **13**C. When the endless belt **13** rotates, a top surface **13**A of the endless belt **13** that opposes the photosensitive drums **8** moves from the one side (front side in the embodiment) to the other side (rear side in the embodiment) in the juxtaposed direction.

The endless belt **13**, the drive roller **13**B, and the follow roller **13**C constitute a belt unit that is detachably mounted in an apparatus body. Here, "apparatus body" denotes portions of the image forming apparatus **1** that a user cannot detach or replace, such as the casing **3** and a pair of main frames **15**A (described later) illustrated in FIG. **2**.

As illustrated in FIG. **1**, a plurality of (four in the embodiment) transfer bodies **14** is provided inside the loop formed by the endless belt **13** at positions confronting corresponding photosensitive drums **8**, with the top surface **13**A interposed therebetween. The transfer bodies **14** are rollers that rotate about rotational axes parallel to the rotational axes of the photosensitive drums **8**. Applying transfer voltages to the transfer bodies **14** causes the developer images carried on the corresponding photosensitive drums **8** to be transferred onto a sheet carried on the top surface **13**A.

The sheet carried on the top surface **13**A moves together with the top surface **13**A from the one side to the other side in the juxtaposed direction. While the sheet resting on the top surface **13**A is moved in the juxtaposed direction, the developer images carried on the four photosensitive drums **8** are sequentially transferred and superimposed on the sheet.

The fixing unit **11** is adapted to fix the developer images transferred onto the sheet by applying heat and pressure to the developer. After an image has been formed on a sheet in this way, discharge rollers **3**A and the like discharge the sheet onto a discharge tray **3**B provided on the top of the casing **3**.

A cover **3**C is provided on a front wall of the casing **3**. A multipurpose sheet-feeding tray (not illustrated) is provided at the cover **3**C. The multipurpose sheet-feeding tray is adapted to hold a plurality of sheets.

A paper tray **17** is disposed at a bottom section of the casing **3**. The paper tray **17** is capable of holding a plurality of sheets stacked therein. The paper tray **17** can be removed from the apparatus body of the image forming apparatus **1** by pulling the paper tray **17** out of the apparatus body toward the one side (front side in the embodiment) in the juxtaposed direction.

Further, as illustrated in FIG. **2**, the image forming apparatus **1** includes the pair of main frames **15**A, a sheet-feeding frame **15**B, a top frame **15**E, and a pair of front and rear frames **15**F.

The main frames **15**A are substantially plate-shaped reinforcing members that are disposed one on either side of the image forming unit **5** in a horizontal direction (left-right direction in the embodiment).

The sheet-feeding frame **15**B as an example of a frame has a beam-like structure that spans between the pair of main frames **15**A. The sheet-feeding frame **15**B is elongated in the horizontal direction. Longitudinal ends (left and right ends in the embodiment) of the sheet-feeding frame **15**B are fixed to the respective main frames **15**A.

The top frame **15**E is disposed above the sheet-feeding frame **15**B. The bottom frames **15**F are disposed below the sheet-feeding frame **15**B. The top frame **15**E connects top edges of the main frames **15**A, while the bottom frames **15**F connect the bottom edges of the main frames **15**A.

2. Sheet Feeding Device

The sheet feeding device provided in the image forming apparatus **1** includes the sheet-feeding frame **15**B, a first

feeding mechanism **19**, a second feeding mechanism **21**, a first roller **23**, a second roller **25**, a first pressing member **27**A, a plurality of (two in the embodiment) second pressing members **27**B, a paper-dust-removing unit **29**, a third roller **31**, a fourth roller **33**, and a detecting unit **37**.

The first feeding mechanism **19** and the second feeding mechanism **21** are provided upstream of the endless belt **13** in a sheet conveying direction.

The first feeding mechanism **19** conveys sheets one at a time from the paper tray **17** toward the image forming unit **5**. As illustrated in FIG. **3**, the first feeding mechanism **19** is provided at the sheet-feeding frame **15**B. The first feeding mechanism **19** includes a pickup roller **19**A, a separating roller **19**B, and a separating pad **19**C.

The pickup roller **19**A contacts the topmost sheet stacked in the paper tray **17** and feeds this sheet toward the separating roller **19**B.

The separating roller **19**B rotates in contact with the sheet supplied by the pickup roller **19**A, applying a conveying force to the sheet.

The separating pad **19**C is positioned in confrontation with the separating roller **19**B and applies a conveying resistance to the sheet. Consequently, if a plurality of sheets is fed by the pickup roller **19**A simultaneously, the separating roller **19**B and the separating pad **19**C separate the plurality of sheets so that they are conveyed to the image forming unit **5** one at a time.

As illustrated in FIG. **1**, the paper tray **17** is disposed in the casing **3** at a position below the image forming unit **5**. Consequently, a sheet-conveying path leading from the paper tray **17** to the image forming unit **5** has a curved section Lo formed in an approximate U-shape.

After the first feeding mechanism **19** feeds the sheet toward the one side (front side in the embodiment) in the juxtaposed direction, the sheet is conveyed along the sheet-conveying path to the image forming unit **5**. In the image forming unit **5**, the sheet travels from the one side (front side in the embodiment) to the other side (rear side in the embodiment) in the juxtaposed direction.

As illustrated in FIG. **3**, the first feeding mechanism **19** and a portion of the sheet-feeding frame **15**B are arranged on an inner circumferential side of the curved section Lo. Here, the inner circumferential side of the curved section Lo implies the side of the curved section Lo on which its center of curvature lies and, hence, the rear side of the curved section Lo in FIG. **3**.

The sheet-feeding frame **15**B includes an inner guide **15**G forming the inner circumferential side of the curved section Lo. An outer guide **36** is provided so as to be supported by the main frames **15**A to form an outer circumferential side of the curved section Lo. The inner guide **15**G and the outer guide **36** serve to guide sheets conveyed along the curved section Lo.

The second feeding mechanism **21** conveys sheets stacked in the multipurpose sheet-feeding tray (not illustrated) toward the image forming unit **5** one at a time. The second feeding mechanism **21** includes a pickup roller **21**A, a separating roller **21**B, and a separating pad **21**C.

The first roller **23** and the second roller **25** are supported in the sheet-feeding frame **15**B at both axial ends (left and right ends in the embodiment) thereof. More specifically, the first roller **23** and the second roller **25** are disposed on an exit side of the curved section Lo, i.e., at a position along the sheet-conveying path on an upstream side of the image forming unit **5** in the sheet-conveying direction. The first roller **23** and the second roller **25** rotate while contacting the sheet. The second roller **25** is disposed at a position confronting the first roller **23** and rotates while pinching the sheet being conveyed together with the first roller **23**. Incidentally, the first roller **23** and the second roller **25** are arranged such that their rotational axes extend in the left-right direction.

A drive force is applied to each of the first roller **23** and the second roller **25**. Through this drive force, the first roller **23** and the second roller **25** are rotated and halted in association with each other. The first roller **23** and the second roller **25** perform a registration function in which the rotations of the first roller **23** and the second roller **25** are temporarily halted when a sheet is conveyed thereto, and in which the rotations of the first roller **23** and the second roller **25** are subsequently resumed to convey the sheet. Therefore, the first roller **23** is also referred to as a registration roller, while the second roller **25** is also referred to as a registration pinch roller.

More specifically, a sheet conveyed by the first feeding mechanism **19** and the second feeding mechanism **21** contacts the first roller **23** and the second roller **25** while the first roller **23** and the second roller **25** are in a halted state, temporarily halting conveyance of the sheet. Subsequently, the first roller **23** and the second roller **25** resume rotating, thereby resuming conveyance of the sheet. In this way, the first roller **23** and the second roller **25** can correct skew in the sheet so that a leading edge of the sheet is orthogonal to the sheet-conveying direction, and can subsequently introduce the sheet into the image forming unit **5** at a predetermined timing.

As illustrated in FIGS. **3** and **5**, the first pressing member **27**A (described later in detail) and the two second pressing members **27**B (described later in detail, only one of the second pressing members **27**B is illustrated in FIG. **5**) are provided at the sheet-feeding frame **15**B. The first pressing member **27**A is provided for pressing an axial center region (left-right center region in the embodiment) of the first roller **23** toward the second roller **25**. The second pressing members **27**B are provided for pressing axial ends (left and right ends in the embodiment) of the first roller **23** toward the second roller **25**.

Hereinafter, a force with which the first pressing member **27**A presses the first roller **23** toward the second roller **25** will be referred to as a first pressing force F1, while a force with which the second pressing members **27**B press the first roller **23** toward the second roller **25** will be referred to as a second pressing force F2. The first pressing member **27**A and the second pressing members **27**B are configured such that the first pressing force F1 is greater than the second pressing force F2.

In the embodiment, the statement that "the first pressing force F1 is greater than the second pressing force F2" indicates that the first pressing force F1 is greater than the force applied by at least one of the second pressing members **27**B disposed on the axial ends of the first roller **23**.

Incidentally, in the embodiment, the first pressing force F1 is set to 1 kgf, and the second pressing force F2 for each of the second pressing members **27**B is set to 200 gf. In other words, the first pressing member **27**A and the second pressing members **27**B in the embodiment are configured such that the first pressing force F1 applied by the first pressing member **27**A is greater than the sum of the second pressing forces F2 applied by both the second pressing members **27**B.

As illustrated in FIG. **4**, the second roller **25** is supported in the sheet-feeding frame **15**B at both axial ends (left and right ends in the embodiment) such that its rotational axis cannot be displaced relative to the sheet-feeding frame **15**B.

More specifically, as illustrated in FIG. **5**, the second roller **25** has a second roller shaft **25**A. Axial ends of the second roller shaft **25**A are rotatably supported in second roller bear-

ings **25**B (only one of the second roller bearings **25**B is illustrated in FIG. **5**). The second roller bearings **25**B are fixed to the sheet-feeding frame **15**B. Thus, the second roller **25** is rotatably supported in the sheet-feeding frame **15**B through the second roller bearings **25**B. In other words, the second roller **25** is supported in the sheet-feeding frame **15**B at both axial ends such that the second roller **25** is capable of rotating about its rotational axis, but cannot be displaced relative to the sheet-feeding frame **15**B.

The first roller **23** is assembled in the sheet-feeding frame **15**B so as to be displaceable relative to the second roller **25** in directions toward and away from the second roller **25** (hereinafter also referred to as contacting/separating directions). The contacting/separating directions are orthogonal to rotational axes of the first roller **23** and the second roller **25**.

More specifically, as illustrated in FIG. **5**, the first roller **23** has a first roller shaft **23**A, and a covering part **23**C. Axial ends of the first roller shaft **23**A extend through elongate holes **15**C formed in the sheet-feeding frame **15**B and are rotatably supported in first roller bearings **23**B (only one of the first roller bearings **23**B is illustrated in FIG. **5**). The elongate hole **15**C has a major diameter aligned in the contacting/separating directions and, that is, in a direction orthogonal to the rotational axis of the second roller **25**. Thus, the first roller **23** is rotatably supported in the sheet-feeding frame **15**B through the first roller bearings **23**B.

The first roller bearings **23**B are provided at the sheet-feeding frame **15**B so as to be movable in the contacting/separating directions. The resilient force of the second pressing members **27**B presses the corresponding first roller bearings **23**B toward the second roller **25** (i.e. in the contacting direction). With this configuration, the first roller **23** is rotatably supported in the sheet-feeding frame **15**B such that the first roller **23** is capable of rotating about its rotational axis and capable of being displaced relative to the rotational axis of the second roller **25** in the contacting/separating directions.

The covering part **23**C covers the first roller shaft **23**A. The covering part **23**C is formed of rubber or another material having a large coefficient of friction. The covering part **23**C is not provided over the axial center region of the first roller **23**, leaving the first roller shaft **23**A exposed in this region. This portion of the first roller shaft **23**A will be referred to as an exposed part **23**D. The first roller shaft **23**A is formed of metal. An outer circumferential surface of the first roller shaft **23**A, at least at the exposed part **23**D, is subjected to a surface treatment, such as chrome plating, to give the surface good wear resistance and a low coefficient of friction. The first roller **23** receives the first pressing force F1 from the first pressing member **27**A at the exposed part **23**D.

As illustrated in FIG. **3**, the first pressing member **27**A includes a contacting part **27**C, and a spring **27**D.

The contacting part **27**C pressingly contacts the outer circumferential surface of the first roller shaft **23**A at the exposed part **23**D. When the first roller **23** rotates, the outer circumferential surface of the first roller shaft **23**A at the exposed part **23**D is in sliding contact with the contacting part **27**C.

The spring **27**D exerts the first pressing force F1 that is applied to the first roller shaft **23**A through the contacting part **27**C.

Since the spring **27**D exerts the first pressing force F1 at one end (upper end in the embodiment) thereof, a reaction force F3 is generated at another end (lower end in the embodiment) of the spring **27**D as a reaction to the first pressing force F1. This reaction force F3 is received by the sheet-feeding frame **15**B at a pressure-receiving part **15**D constituting an approximate longitudinal center region (left-right center region in the embodiment) of the sheet-feeding frame **15**B.

The spring **27**D is a torsion coil spring. The spring **27**D is assembled to the sheet-feeding frame **15**B with an axis of its coil portion oriented parallel to the rotational axis of the first roller **23**. Note that the rotational axes of the first roller **23** and the second roller **25** are aligned with a longitudinal dimension of the sheet-feeding frame **15**B.

The contacting part **27**C is a pressing arm that can pivotally move toward and away from the first roller shaft **23**A about the coil axis of the spring **27**D. When the contacting part **27**C is in contact with the first roller shaft **23**A, an imaginary line L1 passing through the point of contact between the contacting part **27**C and the first roller shaft **23**A and the pivoting axis of the contacting part **27**C is approximately orthogonal to an imaginary line L2 passing through the rotational axes of the first roller **23** and the second roller **25**.

Note that the imaginary line L2 will also be referred to as a normal L2 at a nipping portion where a sheet is nipped between the first roller **23** and the second roller **25**.

The second pressing members **27**B are configured of coil springs. One end of the coil spring constituting each of the second pressing members **27**B is attached to the first roller bearing **23**B, and another end thereof is attached to the sheet-feeding frame **15**B.

The paper-dust-removing unit **29** is disposed on an entrance side of the image forming unit **5**. The paper-dust-removing unit **29** removes paper dust deposited on the sheets. The paper-dust-removing unit **29** includes the second roller **25**, and a charging part **29**A.

The charging part **29**A contacts an outer circumferential surface of the second roller **25** such that the outer circumferential surface of the second roller **25** slides over the charging part **29**A (hereinafter referred to as "slidingly contacts") when the second roller **25** rotates. A contact-receiving part **25**C formed of fluororesin is provided around the circumferential surface of the second roller **25**. When the second roller **25** rotates, the contact-receiving part **25**C slidingly contacts the charging part **29**A. As a result, the contact-receiving part **25**C is tribocharged.

With this configuration, paper dust deposits on the sheets are captured on the charged surface of the second roller **25** by electrostatic attraction. Thus, the second roller **25** also serves as a paper-dust-removing roller. The paper dust attracted to the second roller **25** is subsequently scraped off the second roller **25** by the charging part **29**A.

The third roller **31** and the fourth roller **33** are disposed on an entrance side of the curved section Lo, i.e., at a position along the sheet-conveying path on an upstream side of the first roller **23** and the second roller **25** in the sheet-conveying direction. The third roller **31** and the fourth roller **33** rotate while contacting the sheet. Incidentally, the third roller **31** and the fourth roller **33** are arranged such that their rotational axes extend in the left-right direction.

The third roller **31** is rotatably supported in the sheet-feeding frame **15**B. More specifically, the third roller **31** is assembled in the sheet-feeding frame **15**B such that its rotational axis cannot be displaced relative to the sheet-feeding frame **15**B. The fourth roller **33** as an example of a conveying member rotates while nipping the sheet together with the third roller **31**.

Note that the first roller **23** and the third roller **31** contact one surface of the sheet, while the second roller **25** and the fourth roller **33** contact another surface of the sheet. The surface contacted by the first roller **23** and the third roller **31** faces the inner guide **15**G on the inner circumferential side of the curved section Lo. The surface contacted by the second

roller **25** and the fourth roller **33** faces the outer guide **36** on the outer circumferential side of the curved section Lo.

As illustrated in FIG. **6**, third roller bearings **31**A are fixed to the sheet-feeding frame **15**B for rotatably supporting axial ends of the third roller **31**. Thus, the third roller **31** is rotatably supported in the sheet-feeding frame **15**B through the third roller bearings **31**A. In other words, the third roller **31** is supported in the sheet-feeding frame **15**B at both axial ends such that the third roller **31** is capable of rotating about its rotational axis, but cannot be displaced relative to the sheet-feeding frame **15**B. A drive shaft **31**B coupled to one end (left end in the embodiment) of the third roller **31** applies a drive force to the third roller **31**.

The third roller bearings **31**A are disposed at positions offset from longitudinal ends (left and right ends in the embodiment) of the sheet-feeding frame **15**B toward the longitudinal center region of the sheet-feeding frame **15**B. Thus, the third roller **31** is disposed such that its axial center is disposed at the approximate longitudinal center region of the sheet-feeding frame **15**B.

With this configuration, the third roller bearings **31**A can be positioned in regions offset from the longitudinal ends of the sheet-feeding frame **15**B toward the longitudinal center region of the sheet-feeding frame **15**B. The third roller **31** contacts the sheet at a position in the approximate longitudinal center region of the sheet-feeding frame **15**B.

The axial center of the third roller **31** is positioned to correspond approximately to the exposed part **23**D, i.e., the region of the first roller shaft **23**A of the first roller **23** at which the first pressing member **27**A applies the first pressing force F1. The pressure-receiving part **15**D of the sheet-feeding frame **15**B is positioned on a side opposite to the fourth roller **33** with respect to the third roller **31** (see also FIG. **3**).

As illustrated in FIG. **3**, the fourth roller **33** is disposed at a position confronting the third roller **31** and rotates together with the third roller **31** to convey the sheet nipped therebetween. The fourth roller **33** rotates to follow the movement of a sheet conveyed in the sheet-conveying path.

The fourth roller **33** is rotatably supported in the paper tray **17**. More specifically, the fourth roller **33** is disposed at the paper tray **17** such that its rotational axis can be displaced relative to the rotational axis of the third roller **31**. More specifically, the fourth roller **33** is rotatably supported by a support member **34**. The support member **34** is pivotably assembled to a pivot shaft **17**A provided at the paper tray **17**. The fourth roller **33** is separated from the third roller **31** when the paper tray **17** is pulled out of the apparatus body toward the one side (front side in the embodiment) in the juxtaposed direction.

A spring **35** is provided in the sheet feeding device such that one end of the spring **35** is attached to an end of the support member **34** opposite an end on which the fourth roller **33** is supported, and another end of the spring **35** is attached to the paper tray **17**. The spring **35** exerts a resilient force on the support member **34** for eventually displacing the fourth roller **33** toward the third roller **31**. This configuration generates a nipping force for nipping a sheet at a contacting portion between the third roller **31** and the fourth roller **33** (hereinafter also referred to as a nipping portion).

Hence, the spring **35** serves as a force-generating unit for generating the nipping force. Since the spring **35** applies the resilient force to the support member **34** to pivotally move the fourth roller **33** toward the third roller **31** and thus urges the fourth roller **33** toward the third roller **31**, the resilient force generates an urging force F4 to be applied to the sheet-feeding frame **15**B in a direction away from the fourth roller **33**.

The spring **35** is a tension spring. One end of the spring **35** is connected to the support member **34**, and another end thereof is connected to the paper tray **17**.

The urging force F4 is applied to the longitudinal center region of the sheet-feeding frame **15**B and acts to deform the sheet-feeding frame **15**B in a direction away from the fourth roller **33**. The reaction force F3, on the other hand, is applied to the pressure-receiving part **15**D in the longitudinal center region of the sheet-feeding frame **15**B and acts in a direction for pressing the sheet-feeding frame **15**B toward the fourth roller **33**.

A portion of the sheet-feeding frame **15**B that supports the first roller **23** and the third roller **31** is disposed on the inner circumferential side of the curved section Lo and has the inner guide **15**G forming the inner circumferential side of the curved section Lo. Further, the third roller **31** and the fourth roller **33** are disposed on the entrance side of the curved section Lo, and the first roller **23** and the second roller **25** are disposed on the exit side of the curved section Lo. The outer guide **36** is also disposed on the outer circumferential side of the curved section Lo between the entrance side of the curved section Lo and the exit side of the curved section Lo.

Accordingly, the normal L2 (as an example of a first line) at the nipping portion between the first roller **23** and the second roller **25** intersects a normal L3 (as an example of a second line) at the nipping portion between the third roller **31** and the fourth roller **33** on an inside of the sheet-feeding frame **15**B. The normal L3 also passes through the rotational axes of the third roller **31** and the fourth roller **33**. In other words, the normal L3 is defined by connecting the rotational axis of the third roller **31** to the nipping portion where the sheet is nipped between the third roller **31** and the fourth roller **33**. The spring **27**D is positioned on the curved section Lo side of the intersection point between the normal L2 and the normal L3. In other words, as viewed in an axial direction (left-right direction in the embodiment) of the first roller **23**, the spring **27**D is positioned between the curved section Lo and the intersection point.

The detecting unit **37** is provided at the sheet-feeding frame **15**B and constitutes an actuator of a sensor. The detecting unit **37** is displaced when contacted by a sheet, enabling the sensor to detect the presence of the sheet passing through the registration rollers (i.e., the first roller **23** and the second roller **25**).

The detecting unit **37** can be displaced between a remote position and a proximal position. In the remote position indicated by a double chain line in FIG. **3**, the detecting unit **37** is separated from the exposed part **23**D. In the proximal position indicated by a solid line in FIG. **3**, the detecting unit **37** is adjacent to the exposed part **23**D. A control unit (not illustrated) provided in the image forming apparatus **1** controls image-forming operations, such as the timing of developer image transfers, based on the timing that the detecting unit **37** detects the leading edge of the sheet with respect to the sheet-conveying direction. In the proximal position, the detecting unit **37** is configured to overlap the covering part **23**C as viewed in the axial direction of the first roller **23**.

3. Features of Image Forming Apparatus According to Above-Described Embodiment

As illustrated in FIG. **3**, one feature according to the above-described embodiment is that when the first pressing member **27**A presses the axial center region of the first roller **23** toward the second roller **25**, the reaction force F3 is applied to the sheet-feeding frame **15**B, pressing the sheet-feeding frame **15**B toward the fourth roller **33**.

In this way, the reaction force F3 presses the sheet-feeding frame **15**B toward the fourth roller **33**, while the nipping force generated between the third roller **31** and the fourth roller **33** presses the sheet-feeding frame **15**B away from the fourth roller **33**. Therefore, the reaction force F3 and the nipping force are offset and cancel each other out, thereby restraining deformation of the sheet-feeding frame **15**B.

By suppressing deformation of the sheet-feeding frame **15**B while increasing the nipping force between the first roller **23** and the second roller **25** at the axial center region of the first roller **23** owing to the pressure applied by the first pressing member **27**A, the structure according to the above-described embodiment suppresses a decrease in the nipping force at the axial center region of the first roller **23**.

Here, the statement that the reaction force and the nipping force "are offset and cancel each other out" naturally includes a case in which the net force of the reaction force and the nipping force is zero, but also includes a case in which the magnitude of this net force is smaller than the magnitude of the reaction force or the magnitude of the nipping force.

When the sheet-feeding frame **15**B is formed of resin, stress applied to the sheet-feeding frame **15**B may cause the sheet-feeding frame **15**B to deform through creep, even when a bending moment acting on the sheet-feeding frame **15**B is relatively small.

However, the above-described embodiment can suppress deformation by creep in the sheet-feeding frame **15**B since the reaction force and the nipping force are offset and cancel each other out. Accordingly, the structure according to the above-described embodiment suppresses a decline in the nipping force at the axial center region of the first roller **23** over a long period of time, even when the sheet-feeding frame **15**B is formed of resin.

As another feature according to the above-described embodiment, the second pressing members **27**B are provided to exert the second pressing force F2 for pressing the axial ends of the first roller **23** toward the second roller **25**. Accordingly, the first roller **23** is pressed toward the second roller **25** in at least three locations, including the axial ends and the axial center region of the first roller **23**.

Therefore, this configuration can press the first roller **23** toward the second roller **25** while maintaining the first roller **23** parallel to the second roller **25** with a high degree of precision. Consequently, the first roller **23** and the second roller **25** apply a prescribed nipping force or greater at all points across the width of the sheet being conveyed, thereby conveying the sheet with stability.

Rollers and other long members deform primarily in their longitudinal center regions. Therefore, providing the first pressing force F1 greater than the second pressing force F2 in the above-described embodiment effectively suppresses a drop in the nipping force in the longitudinal center region.

In the above-described embodiment, the sheet-feeding frame **15**B receives the nipping force through the third roller **31**. The third roller bearings **31**A is fixed to the sheet-feeding frame **15**B for rotatably supporting the third roller **31** such that the third roller **31** cannot be displaced relative to the sheet-feeding frame **15**B.

Another feature according to the above-described embodiment is that the fourth roller **33** can be displaced relative to the third roller **31**. Further, the spring **35** serving as a force-generating unit presses the fourth roller **33** against the third roller **31** to generate the nipping force.

Since the spring **35** urges the fourth roller **33** against the third roller **31** supported in the sheet-feeding frame **15**B so as not to be capable of displacing relative to the sheet-feeding frame **15**B, the reaction force F3 and the nipping force can be effectively offset and cancelled out.

By arranging the third roller bearings **31**A closer to the longitudinal center region of the sheet-feeding frame **15**B than the longitudinal ends of the sheet-feeding frame **15**B as described in the embodiment, the nipping force applied through the third roller bearings **31**A is concentrated in the longitudinal center region of the sheet-feeding frame **15**B. Thus, this structure may invite deformation in the longitudinal center region of the sheet-feeding frame **15**B.

However, since the reaction force F3 in the above-described embodiment effectively cancels the nipping force, the structure according to the above-described embodiment suppresses deformation in the sheet-feeding frame **15**B, even though the third roller bearings **31**A are offset from the longitudinal ends of the sheet-feeding frame **15**B toward the longitudinal center region of the sheet-feeding frame **15**B.

In the above-described embodiment, a portion of the sheet-feeding frame **15**B that supports the first roller **23** and the third roller **31** is disposed on the inner circumferential side of the curved section Lo. With this configuration, the first pressing member **27**A can be positioned between the first roller **23** and the sheet-feeding frame **15**B.

In the above-described embodiment, the normal L2 connecting the rotational axis of the first roller **23** to the rotational axis of the second roller **25** intersects the normal L3 connecting the rotational axis of the third roller **31** to the nipping portion where the sheet is nipped between the third roller **31** and the fourth roller **33**, and the intersecting point between the normal L2 and the normal L3 is positioned inside the sheet-feeding frame **15**B on the inner circumferential side of the curved section Lo. With this configuration, the first pressing member **27**A can be positioned close to the intersection point between the normal L2 and the normal L3.

In the above-described embodiment, the first roller **23** has the first roller shaft **23**A, and the rubber covering part **23**C covering the first roller shaft **23**A. Another feature according to the above-described embodiment is that the exposed part **23**D is provided at the axial center region of the first roller **23** and constitutes the region of the first roller shaft **23**A not covered by the covering part **23**C. The exposed part **23**D receives the first pressing force F1.

With this construction, the first pressing force F1 is applied to the portion of the first roller shaft **23**A corresponding to the exposed part **23**D, which is not covered by the covering part **23**C. Therefore, the structure according to the above-described embodiment restrains occurrence of problems such as premature damage to the rubber covering part **23**C.

Another feature according to the above-described embodiment is that the first pressing member **27**A has the contacting part **27**C with which the outer circumferential surface of the metal first roller shaft **23**A at the exposed part **23**D is in sliding contact when the first roller **23** rotates. This configuration according to the above-described embodiment suppresses occurrence of problems such as deformation or premature wear of the first roller **23** by the first pressing force F1.

As described above, the structure according to the above-described embodiment suppresses a drop in the nipping force (pressure at the contact surfaces) in the axial center region of the first roller **23** and the second roller **25**. Therefore, when the second roller **25** also functions as a paper dust removing roller as described in the embodiment, the second roller **25** can apply at least a prescribed nipping force across its entire widthwise dimension. Accordingly, the second roller **25** can effectively remove paper dust.

Another feature according to the above-described embodiment is that the first roller **23** and the second roller **25** have a

registration function for temporarily halting conveyance of the sheet supplied thereto, then subsequently resuming conveyance of the sheet.

In this way, the sheet is thrust into the position between the first roller **23** and the second roller **25** when the first roller **23** and the second roller **25** are in a halted state. Since the first roller **23** and the second roller **25** produce a prescribed nipping force or greater across their entire widthwise dimensions, the first roller **23** and the second roller **25** can reliably halt the leading edge of the sheet to temporarily halt the sheet and can thereby reliably implement their registration function.

The structure according to the above-described embodiment is particularly effective when a sheet having a small widthwise dimension is conveyed through the axial center region of the first roller **23** and the second roller **25**. Since the structure according to the above-described embodiment prevents a drop in the nipping force (pressure at the contact surfaces) in the axial center region of the first roller **23** and the second roller **25**, the first roller **23** and the second roller **25** can reliably implement the registration function.

Another feature according to the above-described embodiment is that the first pressing member **27**A is a torsion coil spring. One end of the first pressing member **27**A exerts the first pressing force F1, while the other end presses against the pressure-receiving part **15**D in the approximate longitudinal center region of the sheet-feeding frame **15**B.

Accordingly, the structure according to the above-described embodiment can exert a large first pressing force F1 within a small mounting space and can eliminate the need for considering distortion by buckling, which is common with coil springs, thereby improving design freedom.

4. Modifications

Various modifications are conceivable. In the following description, only parts differing from those of the above-described embodiment will be described in detail.

In the above-described embodiment, in addition to the first pressing force F1 applied to the axial center region of the first roller **23**, the second pressing force F2 is applied to both axial ends of the first roller **23**. However, the present invention is not limited to this construction, provided that at least the first pressing force F1 is applied.

In the above-described embodiment, the first pressing force F1 is set to a value greater than the second pressing force F2, but the first pressing force F1 may be set to a value equivalent to the second pressing force F2 or a value smaller than the second pressing force F2.

In the above-described embodiment, the contacting part **27**C contacts the first roller shaft **23**A in the exposed part **23**D to apply the first pressing force F1 to the first roller **23**. However, the exposed part **23**D may be eliminated and the first pressing force F1 may be applied to the covering part **23**C through a roller or the like.

In the above-described embodiment, the detecting unit **37** is disposed in a region corresponding to the exposed part **23**D, but the detecting unit **37** may be disposed in another position.

The second roller **25** in the above-described embodiment also functions as a paper dust removing roller, but a separate roller may be provided for this function.

The first roller **23** and the second roller **25** in the above-described embodiment implement a registration function, but these rollers may be simple conveying rollers having no registration function.

The first pressing member **27**A is configured of a torsion coil spring in the above-described embodiment, but the first pressing member **27**A may be configured of a different member, such as a coil spring or a leaf spring.

In the above-described embodiment, a portion of the sheet-feeding frame **15**B that retains the first roller **23** and the third roller **31** is disposed on the inner circumferential side of the curved section Lo, but the sheet-feeding frame **15**B may be disposed in a region along the sheet-conveying path that is not curved, for example.

The sheet-feeding frame **15**B in the above-described embodiment is formed of a resin material, but the sheet-feeding frame **15**B may be formed of a metal material, for example. Alternatively, the sheet-feeding frame **15**B may be formed of a resin material having an embedded metal reinforcing member.

While the fourth roller **33** as an example of a conveying member confronts the third roller **31** in the above-described embodiment, the conveying member confronting the third roller **31** may be implemented by a separating pad.

While the present invention has been described in detail with reference to the embodiment thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the present invention.

What is claimed is:

1. A sheet conveying device configured to convey a sheet along a sheet-conveying path, the sheet conveying device comprising:

a first roller configured to rotate while contacting the sheet, the first roller rotating about a rotational axis extending in an axial direction and having an axial center region in the axial direction;

a second roller disposed in confrontation with the first roller, the second roller being configured to rotate while nipping the sheet in cooperation with the first roller;

a third roller disposed spaced apart from the first roller, the third roller rotating about a rotational axis extending in the axial direction and being configured to rotate while contacting the sheet;

a conveying member disposed in confrontation with the third roller, the conveying member being configured to nip the sheet in cooperation with the third roller;

a frame elongated in the axial direction and supporting the third roller;

a first pressing member configured to apply a first pressing force to the axial center region of the first roller to press the first roller toward the second roller, the first pressing member being further configured to apply, to the frame, a reaction force generated as a reaction to the first pressing force to press the frame in a direction toward the conveying member; and

a force-generating unit configured to generate a nipping force for nipping the sheet between the third roller and the conveying member, the force-generating unit being further configured to apply an urging force to the frame in a direction away from the conveying member.

2. The sheet conveying device as claimed in claim **1**, wherein the first roller has axial end portions in the axial direction,

the sheet conveying device further comprising: a second pressing member configured to apply a second pressing force to the axial end portions of the first roller to press the first roller toward the second roller.

3. The sheet conveying device as claimed in claim **2**, wherein the first pressing force is greater than the second pressing force.

4. The sheet conveying device as claimed in claim **1**, wherein the frame includes a bearing portion for rotatably

supporting the third roller such that displacement of the rotational axis of the third roller is prohibited relative to the frame,

wherein the conveying member is configured to be displaced relative to the rotational axis of the third roller; and

wherein the force-generating unit is configured to urge the conveying member toward the third roller to generate the nipping force.

5. The sheet conveying device as claimed in claim **4**, wherein the frame has a longitudinal center region and a longitudinal end portion in the axial direction,

wherein the bearing portion is disposed offset from the longitudinal end portion of the frame toward the longitudinal center region of the frame.

6. The sheet conveying device as claimed in claim **1**, wherein the sheet-conveying path has a curved section at a position between the first roller and the third roller, the curved section defining an inner circumferential side at which the first roller and the third roller are positioned,

wherein the frame has a portion that supports the third roller, the portion being disposed on the inner circumferential side.

7. The sheet conveying device as claimed in claim **6**, wherein the first roller and the second roller defines a first line connecting the rotational axis of the first roller to a rotational axis of the second roller, and the third roller and the conveying member defines a second line connecting the rotational axis of the third roller to a nipping portion where the sheet is nipped between the third roller and the conveying member,

wherein the first line intersects the second line inside the frame on the inner circumferential side.

8. The sheet conveying device as claimed in claim **1**, wherein the first roller includes a first roller shaft and a covering part configured to cover the first roller shaft, the covering part being formed of rubber,

wherein the first roller has an axial center region in the axial direction where the first roller shaft is exposed to provide an exposed part, the first roller being configured to receive the first pressing force from the first pressing member at the exposed part.

9. The sheet conveying device as claimed in claim **8**, wherein the first roller shaft is formed of metal and has an outer circumferential surface,

wherein the first pressing member includes a contacting part configured to be in sliding-contact with the outer circumferential surface of the first roller shaft at the exposed part.

10. The sheet conveying device as claimed in claim **8**, further comprising a detecting unit configured to be displaced between a proximal position where the detecting unit is adjacent to the exposed part and a remote position where the detecting unit is separated from the exposed part to detect a presence of the sheet.

11. The sheet conveying device as claimed in claim **10**, wherein the remote position is provided upon contacting of a leading edge of the sheet passing between the first roller and the second roller with the detecting unit, the sheet being detected in response to displacement of the detecting unit from the proximal position to the remote position.

12. The sheet conveying device as claimed in claim **1**, wherein the second roller is a paper dust removing roller configured to remove paper dust deposited on the sheet by electrostatic attraction.

13. The sheet conveying device as claimed in claim **1**, wherein the first roller and the second roller have a registration function configured to temporarily halt conveyance of the sheet conveyed to a position between the first roller and the second roller and to subsequently resume conveyance of the sheet.

14. The sheet conveying device as claimed in claim **1**, wherein the first pressing member comprises a torsion coil spring having one end configured to exert the first pressing force on the first roller and another end configured to press against the frame.

15. An image forming apparatus comprising:

a sheet conveying device configured to convey a sheet along a sheet-conveying path, the sheet conveying device comprising:

a first roller configured to rotate while contacting the sheet, the first roller rotating about a rotational axis extending in an axial direction and having an axial center region in the axial direction;

a second roller disposed in confrontation with the first roller, the second roller being configured to rotate while nipping the sheet in cooperation with the first roller;

a third roller disposed spaced apart from the first roller, the third roller rotating about a rotational axis extending in the axial direction and being configured to rotate while contacting the sheet;

a conveying member disposed in confrontation with the third roller, the conveying member being configured to nip the sheet in cooperation with the third roller;

a frame elongated in the axial direction and supporting the third roller;

a first pressing member configured to apply a first pressing force to the axial center region of the first roller to press the first roller toward the second roller, the first pressing member being further configured to apply, to the frame, a reaction force generated as a reaction to the first pressing force to press the frame in a direction toward the conveying member; and

a force-generating unit configured to generate a nipping force for nipping the sheet between the third roller and the conveying member, the force-generating unit being further configured to apply an urging force to the frame in a direction away from the conveying member; and

an image forming unit configured to form an image on the sheet conveyed by the sheet conveying device.

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